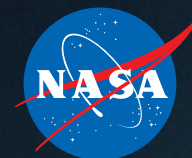


National Aeronautics and Space Administration



# COMM & NAV 2021 FY ANNUAL REPORT



[esc.gsfc.nasa.gov](https://esc.gsfc.nasa.gov)



# MESSAGE FROM THE ASSOCIATE DIRECTOR

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Fiscal year (FY) 2021 was a year of outstanding achievements for the Goddard Space Flight Center Communications and Navigation Community. Each and every person — remote or in person — has shown the tremendous effectiveness this community has. I want to thank all of you for your dedication and perseverance during this virtual work posture as we navigate an unprecedented global pandemic.

This year, our reorganization was in full effect. The Near Space Network (NSN) seamlessly supported 17 launches and synthesized comprehensive services from government and commercial service providers. Our new networking posture embraces NASA's goal for increased commercialization while balancing the needs of our users. Additionally, the new Commercialization, Innovation, and Synergies (CIS) office has done an exemplary job connecting with the aerospace community, hosting over 50 events with industry, mission teams, and other government agencies. Through this work, we are expanding the communications and navigation marketplace and identifying common goals.

We also had several other accomplishments in areas like optical communications, quantum research, networking, navigation, outreach, and more. As you will witness throughout this report, the Communications and Navigation Community spent FY 2021 diligently working toward our goals, innovating solutions, and advancing exploration capabilities.

None of the accomplishments outlined in this report could have been achieved without the support from our leaders within NASA's Space Communications and Navigation (SCaN) program office, which the Exploration and Space Communications (ESC) projects division is proud to support.

A handwritten signature in blue ink, appearing to read 'RJM', with a large, stylized flourish extending to the right.

Robert J. Menrad  
Associate Director of Flight Projects,  
Exploration and Space Communications

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# EXPLORATION AND SPACE COMMUNICATIONS

## EXECUTIVE LEADERSHIP TEAM

Associate Director:  
**Bob Menrad**

Deputy Program Manager/  
Strategic Partnerships:  
**Mark Brumfield**

Deputy Program Manager/Execution:  
**Vir Thanvi**

Deputy Program Manager/Implementation:  
**Glenn Jackson**

Associate Program Manager:  
**La Vida Cooper**

Program Business Manager:  
**Chris Grau**

Architect:  
**Dave Israel**

## MISSION STATEMENT

As a national resource, ESC enables human and robotic endeavors in space by providing innovative and mission-effective communications, navigation, and exploration solutions to the largest community of diverse users.

## VISION STATEMENT

We are collaborative leaders extending the reach of humanity's quest for discovery and passion for knowledge as sought-out experts worldwide. ESC community members are trusted providers of innovative exploration, communications, and navigation solutions.

## OVERVIEW

ESC provides communications and navigation services as well as technical expertise to missions in the near-Earth region. These services are critical to operating NASA's spacecraft and returning ground-breaking data to Earth.

ESC develops new communications capabilities, like optical and quantum communications; creates unique networking solutions, such as Delay/Disruption Tolerant Networking; provides mission-critical services to missions, both robotic and human; and improves upon existing technologies, including emergency location beacons and autonomous navigation software.

Our community is made up of dedicated engineers, visionaries, architects, and more, who advance NASA's communications and navigation capabilities. These experts approach each challenge with innovative solutions, driving the agency forward.

# ESC BUDGET AND WORKFORCE

## BUDGET PROFILE FY21 (DIRECT & REIMBURSABLE)







# NEAR SPACE NETWORK PROJECT

## LEADS

Project Manager: **Vir Thanvi (Acting)**

Deputy Project Manager: **Carrie White**

Deputy Project Manager/Technical: **Brandon Bethune**

Deputy Project Manager/Resources: **Cristy Wilson**

The Near Space Network (NSN) serves robotic, technology, and human space flight missions from the launch pad to a million miles away, providing comprehensive communications and navigation services through a blend of commercial and government providers. The network serves missions throughout their entire lifecycle, enabling requirements analysis, spectrum management, communications analysis, service agreements, mission design, mission planning, launch, operations, and post-mission support activities. Missions within two million kilometers of Earth can rely on the expertise of NSN engineers to get their science, exploration, and mission health data to Earth.

## FY 21 HIGHLIGHTS

- In FY21, NSN supported 17 launches, seamlessly integrating support from service provider ACCESS, NASCOM, the Flight Dynamics Facility, and the Search and Rescue office.
- In particular, the network supported the successful launch and docking of the SpaceX Crew-1 and Crew-2 missions as part of NASA's Commercial Crew Program. These missions brought eight astronauts to and from the International Space Station on a U.S. commercial spacecraft.
- NSN supported the International Space Station during recovery from an attitude control anomaly. The anomaly was caused by uncontrolled firing of thrusters from a newly docked module, causing the station to cartwheel. The NSN team quickly enabled support from all network elements and placed experts on-console to re-establish communication links and assist in space station recovery to a nominal state.

**17**  
**LAUNCHES**  
**SUPPORTED**

**2.1**  
**MILLION** DIRECT-TO-EARTH  
MINUTES SUPPORTED

**10.6**  
**MILLION** RELAY MINUTES SUPPORTED

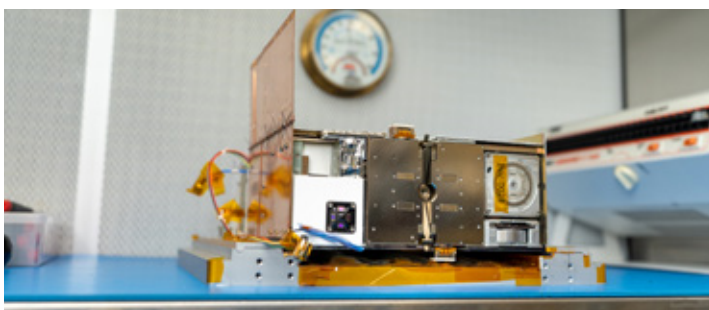
# COMMERCIALIZATION, INNOVATION, AND SYNERGIES OFFICE

## LEADS

Chief: **Neal Barthelme (Acting)**  
Senior Resources Analyst: **Missy Rice**

The Commercialization, Innovation, and Synergies (CIS) office advances the communications and navigation community's partnerships by creating prosperous relationships with mission teams, industry, academia, and other government agencies. The office is dedicated to increasing the industry provider base for the Near Space Network while identifying future technology needs and investing in early-stage capabilities for further development. CIS also serves as the agency's lead in the 3rd Generation Partnership Project, an organization known for the development and maintenance of mobile telecommunications standards.

Additionally, the office has a team dedicated to supporting current and future exploration efforts for NASA. This team works with centers across the agency to create innovative plans and instruments for NASA's Artemis program.



## FY 21 HIGHLIGHTS

### OUTREACH:

- The Industry Engagement team hosted a series of outreach events, including forums and one-on-one meetings. In total, the team reached over 200 companies interested in collaborating with NASA.
- The Civil and Defense Space Partnerships team hosted, as well as attended, 26 inter-agency events to identify common goals and build prosperous relationships between NASA and other government agencies.
- The CIS Mission Engagement team visited 12 Goddard projects as part of a comprehensive in-reach effort to advertise Near Space Network capabilities. They made mission teams aware of solutions the network can provide and built excitement within the scientific community.
- The CIS team finalized and released the Capability Study Appendix O Broad Agency Agreement. This will enable CIS to help guide NASA in establishing the standards, technology, and mechanisms to advance commercialization efforts and create an interoperable space communications ecosystem.

### EXPLORATION:

- The Goddard-developed Broadband InfraRed Compact High-Resolution Exploration Spectrometer (BIRCHES) was successfully built and integrated into the Lunar IceCube spacecraft (pictured left), a secondary payload on the Artemis I mission that will study ice on the Moon.
- The Lunar IceCube spacecraft successfully passed environmental testing at Goddard and was delivered to Kennedy Space Center for integration into the Space Launch System.





# ACCESS

## ADVANCED COMMUNICATIONS CAPABILITIES FOR EXPLORATION AND SCIENCE SYSTEMS PROJECT

### LEADS

Project Manager: **Ted Sobchak**

Deputy Project Manager: **Risha George**

Deputy Project Manager/Technical: **Dave Larsen**

Deputy Project Manager/Resources: **Michelle Hamilton**

The Advanced Communications Capabilities for Exploration and Science Systems (ACCESS) project is a service provider for the Near Space Network. ACCESS operates and maintains NASA communications systems that operate 24-7, 365 days a year, providing critical services to robotic and human exploration missions.

Additionally, the project is advancing optical communications capabilities by creating low-cost optical ground terminals and preparing to support the operations of optical systems like the Laser Communications Relay Demonstration (LCRD) and the Orion Artemis II Optical Communications System (O2O).

**177,719**

SPACE RELAY  
HOURS OF SERVICE



**14,476**

DIRECT-TO-EARTH  
HOURS OF SERVICE

### FY 21 HIGHLIGHTS

- The STPSat-6 Antenna and Ground Equipment (SAGE) and LCRD Mission Operations Center teams successfully completed operational readiness reviews and are ready to support LCRD operations after its successful launch.
- The network made significant progress on the NSN Initiative for Ka-band Advancement (NIKA) effort. The team installed and completed acceptance testing for antennas in Fairbanks, Alaska; Punta Arenas, Chile; Svalbard, Norway; and Wallops Island, Virginia.
- The ACCESS project successfully transferred all remaining SGSS work from the development contractor.
- The ACCESS project completed the final ground segment system design review for O2O. The O2O ground segment is a multi-organizational effort that leverages optical communications technologies and expertise from across the agency.
- ACCESS operations teams successfully helped Landsat 8, Hubble Space Telescope, and the International Space Station during spacecraft emergencies.



# SPACE NETWORK GROUND SEGMENT SUSTAINMENT

## PRIOR SGSS LEADS

Project Manager: *Carrie White*

Deputy Project Manager: *Tom Gitlin*

Deputy Project Manager/Resources: *Beverly Thomas*

The Space Network Ground Segment Sustainment (SGSS) project implemented critical upgrades to NASA's space communications infrastructure. The team designed, tested, and installed new equipment at the White Sands Complex (WSC) in Las Cruces, New Mexico. These upgrades modernized NASA's Tracking and Data Relay Satellite (TDRS) ground systems.

Orbiting 22,300 miles above Earth, multiple TDRS spacecraft provide communications between orbiting spacecraft and their ground-based control centers. The TDRS system allows missions to be in near-constant contact with their control and data centers on Earth.

In April 2021, the SGSS team finished upgrades to systems at the Second TDRS System Ground Terminal (STGT) and the White Sands Ground Terminal (WSGT) sites.

The improvements allow more data to flow through the system, create additional data transfer modes, and increase antenna reliability.

## FY 21 HIGHLIGHTS

- At conclusion, the SGSS project:
  - Modified and completed acceptance testing for one main mission antenna at WSGT.
  - Tested 2nd generation TDRS support capability.
  - Successfully demonstrated TDRS and user operations capabilities.
  - Installed STGT and WSGT ground equipment.
  - Delivered engineering design documentation.
  - Completed operations and maintenance personnel training.
- The SGSS project completed an Interim Operations Capability Test Readiness (IOC-TR) review in February 2021, officially starting the transition of the SGSS system to ACCESS. ACCESS is expected to continue testing and deployment of the SGSS system components.





# SEARCH AND RESCUE OFFICE

## LEADS

Chief: **Lisa Mazzuca**

Deputy Chief: **Tony Foster**

Mission Manager of National Affairs: **Cody Kelly**

Senior Resources Analyst: **Missy Rice**

NASA's Search and Rescue (SAR) office is the technology development lead for the international Cospas-Sarsat program, a cooperative effort between 45 member countries and organizations dedicated to providing robust and reliable satellite-aided distress location services worldwide.

NASA's SAR office has been integral to designing and testing Cospas-Sarsat's 406 MHz distress beacons, as well as the flight and ground systems that support them. Additionally, the office investigates technology innovations, developing locator beacons for Artemis astronauts, conducting safety studies, enhancing aircraft safety, supporting human space flight missions like the Commercial Crew Program, and envisioning search and rescue capabilities on the Moon.



## FY 21 HIGHLIGHTS

- The SAR office defined standardized lunar distress message formats and waveforms for the LunaNet architecture. SAR was successful in advocating for dedicated UHF-band SAR frequency allocations within NASA and will present findings to the Space Frequency Coordination Group in 2022.
- SAR supported Underway Recovery Test-9, demonstrating situational awareness tools for tracking SARSAT beacons during Orion rescue and recovery operations. The office will complete SARSAT-specific flight test objectives following Artemis I while providing assured capsule location capability for NASA and Department of Defense forces during post-landing mission phases.
- The SAR office conducted in-water testing with an Emergency Position Indicating Radio Beacon, a maritime distress beacon. The test was used to refine an in-house model showing how wave motion affects beacon movement. Slow-moving beacon location algorithm development plays a crucial role in recovery of the Orion capsule following its journey to the Moon.

**SAR SAVES  
IN FY21**



# TEMPO

## TECHNOLOGY ENTERPRISE AND MISSION PATHFINDER OFFICE

### LEADS

Chief: **Kendall Mauldin**

Deputy Chief: **Bradley Hill**

Financial Management Specialist: **Lauren Tokarcik**

The Technology Enterprise and Mission Pathfinder Office (TEMPO) organizes, incubates, and infuses mission-enabling communications and navigation technologies and projects, nurturing some of NASA's most ambitious science and technology missions. The TEMPO team undertakes a wide variety of breakthrough efforts, leading mission-enabling concept studies, identifying cross-cutting solutions to capability gaps, initiating and overseeing technology infusion, performing experiments and evaluations, and applying entrepreneurial methods to deliver results.



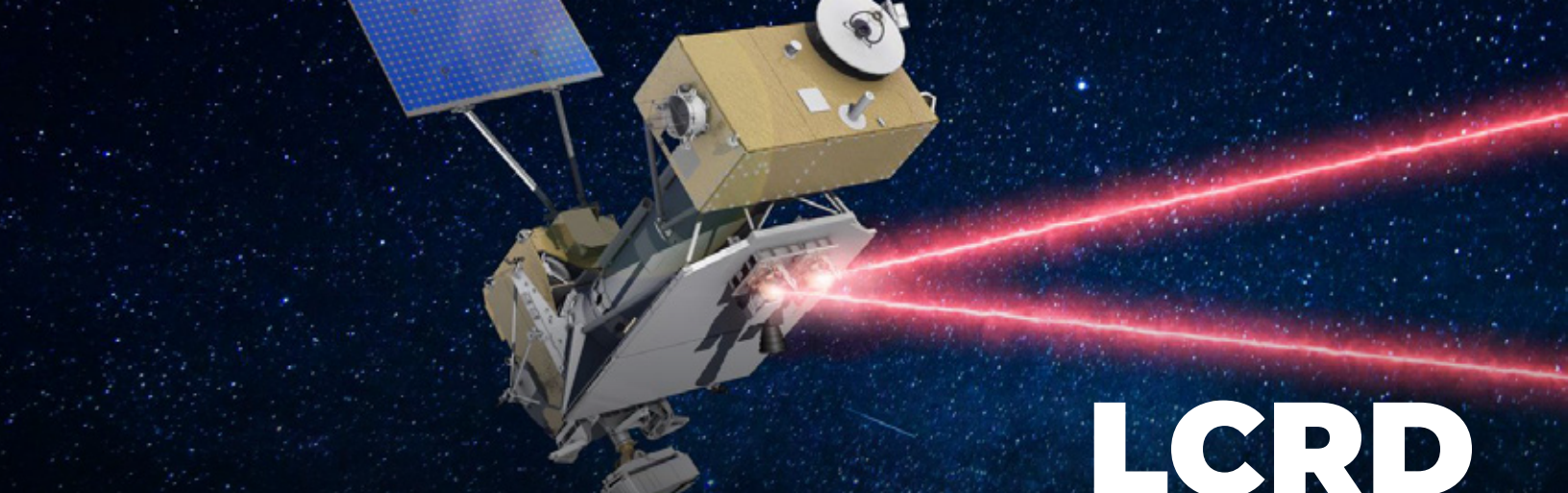
16 IRADS FUNDED

27 SIGNIFICANT ACTIVITIES SUPPORTED OR LED BY THE TEMPO PORTFOLIO

### FY 21 HIGHLIGHTS

- A total of 16 communications and navigation IRADS were successfully executed with oversight and facilitation by TEMPO on behalf of the Communications and Navigation Line of Business. These IRADS lead to many capability and technology advancements.
- TEMPO successfully integrated the Terabyte Infrared Delivery (TBIRD) mission's optical subassembly and completed integration and testing.
- The Lunar Communications Relay and Navigation Services (LCRNS) project was successfully incubated within TEMPO and will establish the first NASA-provided relay node orbiting the Moon. LCRNS will soon be a stand-alone project within the division.
- The TEMPO and navigation teams kicked off activities for the Lunar GNSS Receiver Experiment (LuGRE) pathfinder mission, which will obtain the first GNSS fix on the lunar surface.
- The Delay/Disruption Tolerant Networking Infusion Project released ground software for the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission and its ground stations.
- The TEMPO team successfully concluded a highly beneficial joint capability study with Joint Polar Satellite System, investigating future capabilities through this strong partnership.





# LASER COMMUNICATIONS RELAY DEMONSTRATION

## LEADS

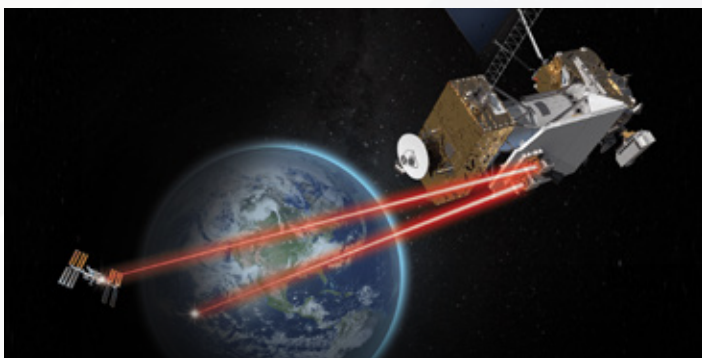
Principal Investigator: **Dave Israel**

Project Manager: **Glenn Jackson**

Deputy Project Manager/Technical: **Nidhin Babu**

Deputy Project Manager/Resources: **Jonathan Bryson**

NASA's Laser Communications Relay Demonstration (LCRD) mission will be the agency's first two-way optical relay system. LCRD will display the vast capabilities of laser communications technologies, beaming data between geosynchronous orbit and ground stations in California and Hawaii. During its first few years, LCRD will conduct experiments in partnership with industry, academia, and other government agencies to further refine optical communications knowledge and functionality. After the experimental phase, LCRD will support orbital missions below geosynchronous orbit.



## LCRD DECEMBER 2021

## FY 21 HIGHLIGHTS

- The LCRD team completed mission readiness test 4 and end-to-end rehearsal — both major milestones. The team practiced payload activation objectives, normal operation procedures, and experimentation scenarios in preparation for launch.
- LCRD successfully shipped from Virginia to Cape Canaveral, Florida and completed post-shipment inspections.
- LCRD and STPSat-6 passed Launch Integration Systems Testing – the last Earth-based test for the spacecraft.
- LCRD team successfully completed the operational readiness review with the standing review board and closed all open request or actions.
- The LCRD Ground Segment and Mission Integration teams completed ground readiness testing, sending data through Optical Ground Station (OGS)-1 in California, OGS-2 in Hawaii, and the Payload to Ground Link Terminal at the LCRD Mission Operations Center in New Mexico.
- LCRD subject matter experts participated in over 20 internal and external outreach events, educating the public on the mission and the benefits of optical communications.



# ILLUMA-T

## INTEGRATED LCRD LOW-EARTH ORBIT USER MODEM AND AMPLIFIER TERMINAL

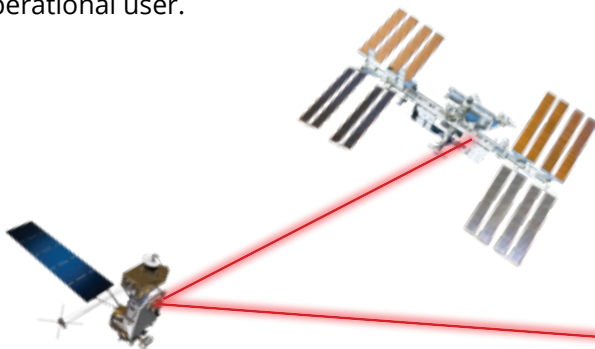
### LEADS

Project Manager: **Chetan Sayal**

Deputy Project Manager: **Cathy Peddie**

Financial Management Specialist: **Mark Wagner**

NASA's Integrated LCRD Low-Earth Orbit (LEO) User Modem and Amplifier Terminal (ILLUMA-T) will provide astronauts and experiments aboard the International Space Station with enhanced data capabilities. The terminal will leverage optical communications to send high-resolution information from the space station to LCRD in geosynchronous orbit, which will then relay that data down to Earth. ILLUMA-T will be LCRD's first operational user.



# 1.244

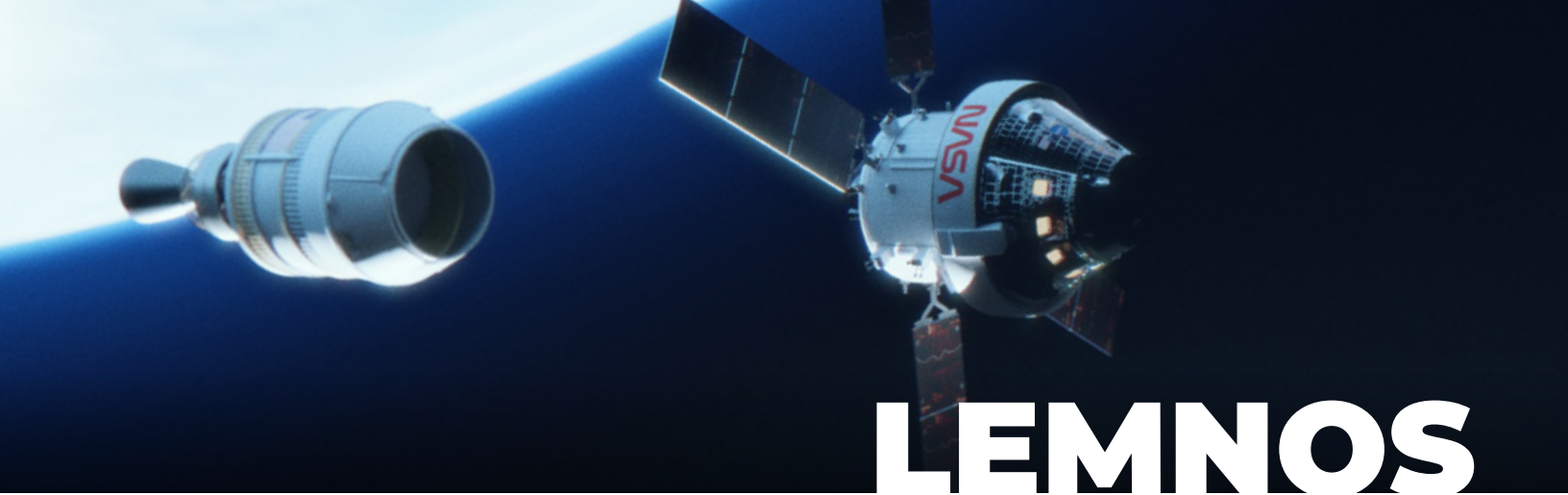
GIGABITS PER SECOND  
(GBPS)

### FY 21 HIGHLIGHTS

The ILLUMA-T team completed design, build, assembly, and testing for multiple payload components. The team:

- assembled and aligned the optical module.
- tested and selected two media converters.
- installed and tested the power converter units.
- completed space station interface testing.
- finalized flight sled development.
- passed critical design review for the ground segment.





# LEMNOS

## LASER-ENHANCED MISSION COMMUNICATIONS, NAVIGATION, AND OPERATIONAL SERVICES PIPELINE

### LEADS

Project Manager: **Steve Horowitz**  
Deputy Project Manager/Technical: **Richard Slonaker**  
Financial Management Specialist: **Mark Wagner**

The Laser-Enhanced Mission Communications, Navigation, and Operational Services (LEMNOS) Pipeline project oversees the development of NASA's Orion Artemis II Optical Communications System (O2O). Launching in 2024, Artemis II will be the first crewed mission beyond low-Earth-orbit since Apollo. It will also be the first crewed mission to the Moon to use optical communications technologies. O2O will provide Artemis II with ultra-high-definition video and enhanced science data transmission during its ten-day mission to and from the Moon.

80  
MBPS



### FY 21 HIGHLIGHTS

The LEMNOS O2O team:

Completed design, manufacturing, assembly, and testing of all payload components, including:

- Optical Module
  - Back-end Optical Assembly
  - Telescope and Relay Assembly
  - Latch and Gimbal Assembly
  - Integration and alignment
  - Vibration and post-vibration testing
- Controller Electronics Module
  - Controller Electronics
  - Vibration and post-vibration testing
- Inner Wall Assembly
  - Power Control Unit
  - Modem Module
  - Vibration and post-vibration testing

# INSPIRE

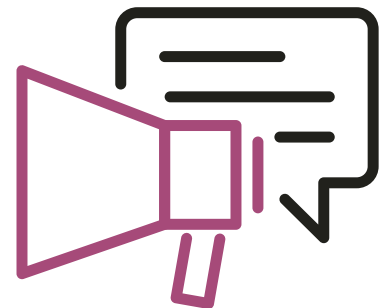
## INTEGRATED STRATEGIC PRODUCTS, INFORMATION, AND RESOURCES ENTERPRISE

### LEADS

Chief: **Dan Tani**

Senior Resources Analyst: **Missy Rice**

The INTeGrated Strategic Products, Information, and Resources Enterprise (INSPIRE) office supports ESC with communications and outreach activities. The team shares the importance of space communications and navigation with the general public, educators, students, NASA, other government agencies, industry partners, and the overall aerospace community. Through technical writing, design, strategic communications, digital media, social media, and more, the office reaches people worldwide to share the story of communications and navigation technologies.



**2,669,199** IMPRESSIONS MADE  
ON SOCIAL MEDIA

**34**  
INTERNAL  
BULLETINS  
SENT OUT

**68** INTERNS  
HOSTED  
THROUGH  
SPRING,  
SUMMER,  
AND FALL

**14**  
TECHNICAL PAPERS  
PUBLISHED

**14**  
ARTICLES ON  
NASA.GOV

**27**  
ARTICLES ON  
ESC BLOG

**13**  
INTERVIEWS  
CONDUCTED

**27**  
AWARDS WON

**~22,000,000** REACHED  
THROUGH PSC  
EFFORTS

**66,690**  
FOLLOWERS GAINED ON  
SOCIAL MEDIA

**5** PODCAST  
EPISODES  
PRODUCED



# COLLABORATING ORGANIZATIONS

## RESOURCES

Lead: **Chris Grau**

ESC's business branch provides all program planning and control implementation and oversight to the division's projects and offices. Our resources team executes each project's budget, along with all formulation responsibilities required for the annual budget submittals, which includes workforce management. They ensure each budget is aligned to maintain mission success and carries out the division's vision and goals.

## SYSTEMS ENGINEERING

Lead: **Eric Poole**

Experienced engineers enable scientific and technological advancement by providing systems engineering expertise for the NASA activities that span the entire life cycle from advanced concepts through implementation. Our systems engineers act as the technical authority for ESC, coordinating multiple flight projects, network assets, and technological pursuits. They perform capability assessments, create technology roadmaps, and develop infusion plans.

## NAVIGATION

Navigation Lead: **Cheryl Gramling**  
Flight Dynamics Director: **Sam Schreiber**  
PNT Policy Lead: **Joel Parker**

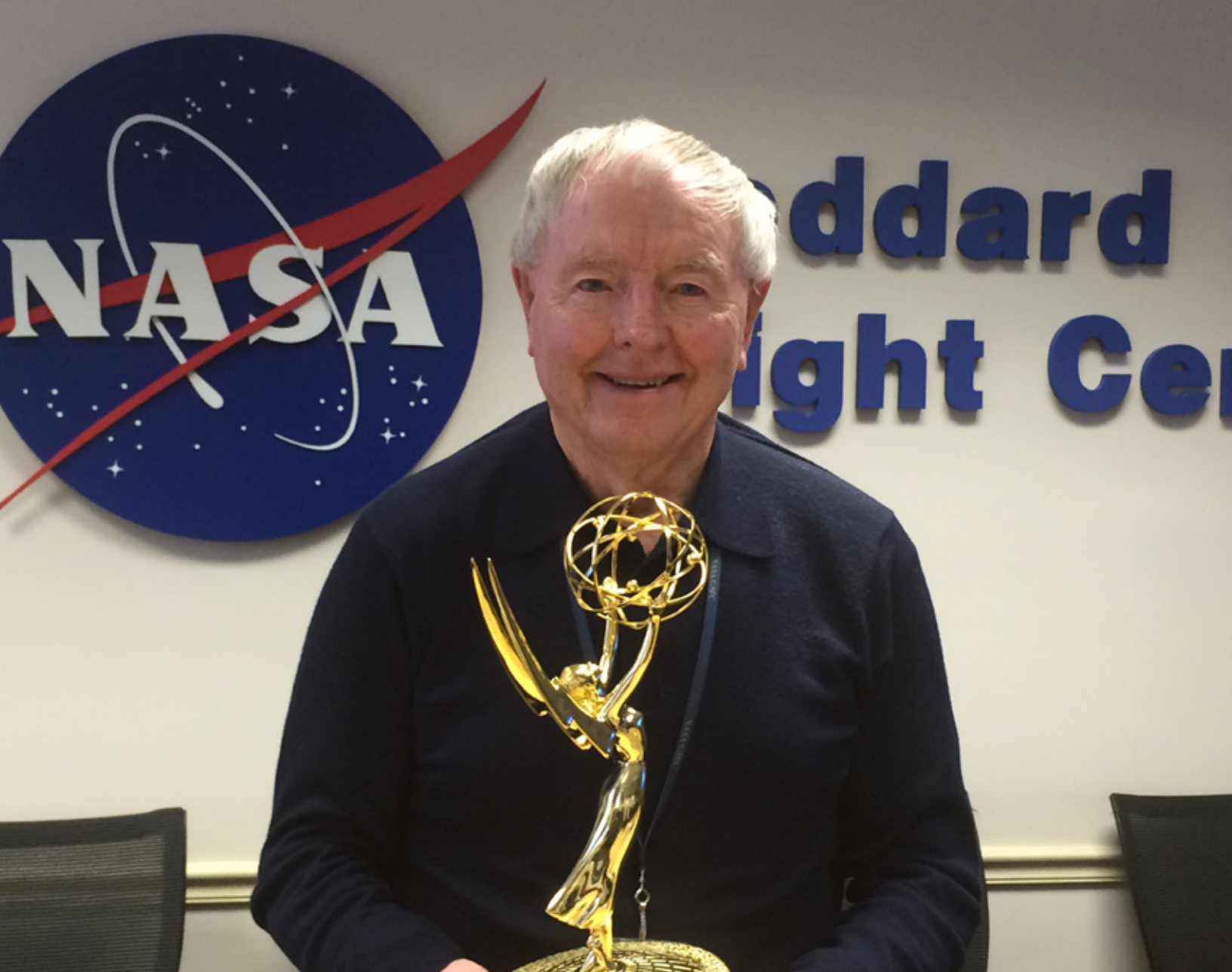
Goddard's missions need navigation data to successfully reach their destinations and execute their science and exploration objectives. Navigation engineers serve NASA in a variety of ways, by analyzing mission trajectories and developing technologies that enhance spacecraft navigation and guidance. The world-renowned space navigation experts at ESC design the satellite navigation systems and architectures of the future while serving as experts on the international stage.

## SAFETY AND MISSION ASSURANCE

Lead: **Sanjeev Sharma**

The Safety and Mission Assurance (SMA) team analyzes the communications and navigation community's projects, assessing risks, ensuring protocol is followed, and documenting any mishaps. This ensures each mission is successful and meets all its performance goals. In addition, SMA contributes to and applies policy guidelines set by NASA Headquarters and the Goddard Center Director.





# FRANK STOCKLIN

## SPECIAL RECOGNITION



Frank and Inge Stocklin, August 26, 1961.

Frank Stocklin was one of NASA's premier radio frequency engineers, providing critical link calculations to hundreds of NASA missions over his storied career. He began his career working on the Apollo missions and in 2009 he and his team won a Primetime Emmy award for the 1969 Apollo 11 Moon landing television broadcast, which was viewed by 600 million people around the world. Frank's work in the late 1960s directly contributed to NASA's first journey to the Moon.

As radio frequency analyzer, his work touched nearly all of NASA's near-Earth missions in the last five decades. Frank played a vital role in determining mission requirements, developing creative ground solutions, calculating mission margins, and implementing hardware. His work enabled mission teams to receive science data at Science Operations Centers around the world, allowing scientists to unlock the mysteries of the universe

Frank took mission requirements, conducted trade studies, and worked with each mission he supported to determine what was feasible and refine implementation approaches. He was instrumental in the design of the Tracking Data and Relay Satellites (TDRS) nearly 30 years ago. Specifically, he was instrumental in developing NASA's communications link model, which puts the size, weight, and power burdens on the ground segment, reducing the burden on the spacecraft side. This change has saved the agency millions of dollars.

Frank exhibited the utmost professionalism, fostering relationships across NASA and the aerospace community. He built trust among his colleagues, who routinely consulted with him on all things space communications. He was respectful of everyone he encountered, from new interns to the NASA Administrator.

Frank's impact on the agency and our community cannot be overstated. His decades of expertise have enabled the delivery of terabytes of science data, furthering NASA's mission to explore new heights for the benefit of all.

Frank will be greatly missed but never forgotten.



Frank Stocklin at a formal event.



Ka-band upgrade team, November, 2015.



Frank Stocklin and 450 team, circa 1990.





Exploration  
& **SPACE**  
Communications



**EXPLORATION AND  
SPACE COMMUNICATIONS  
PROJECTS DIVISION**

FY21 REPORT

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